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SPARSE CHANNEL ESTIMATION FOR ORTHOGONAL FREQUENCY DIVISION MULTIPLEXED SIGNALS

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SPARSE CHANNEL ESTIMATION FOR ORTHOGONAL FREQUENCY DIVISION MULTIPLEXED SIGNALS

FIELD OF THE INVENTION

The invention relates generally to communication systems and, more particularly, to techniques and structures for performing channel estimation in such systems.

BACKGROUND OF THE INVENTION

After a communication signal has traveled through a communication channel, equalization is often performed on the received signal to remove channel effects from the signal. One of the channel effects that often needs to be removed is intersymbol interference (ISI). In a wireless communication system, ISI is typically present in the form of multipath interference. That is, a transmit signal travels through the wireless channel via multiple different paths that each have a different channel delay. For example, one signal component may travel in a direct path from the transmitter to the receiver while one or more other signal components are reflected from objects in the surrounding environment toward the receiver. As can be appreciated, the signal component that travels directly to the receiver will typically be the first to arrive at the receiver and have the largest amplitude. The reflected components will typically arrive at the receiver sometime later and have smaller amplitudes. Although smaller in amplitude, the reflected signals can interfere with the direct signal making it more difficult to accurately detect the data therein. Equalization is thus used in the receiver to reduce or eliminate the negative channel effects from the received signal to improve the likelihood of accurate detection.

In most equalization techniques, an estimate of the present channel response is first determined. The channel estimate is then used to process the received signal to remove the negative channel effects. The channel estimation process is often a computationally complex and time consuming process. That is, performance of such processes will often consume a large percentage of system resources and may introduce

undesirable delays in the receiver processing. As can be appreciated, it is generally desirable to reduce computational complexity and processing delays within a communication system. This is especially true within handheld and portable communication units that have limited processing capabilities and a limited supply of

5   power (e.g., batteries). Therefore, there is a need for channel estimation techniques and structures that are computationally efficient while still providing accurate estimates.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating a conventional orthogonal frequency

10   division multiplexing (OFDM) transmitter;

Fig. 2 is a signal diagram illustrating an OFDM symbol stream that may be transmitted from the transmitter of Fig. 1;

Fig. 3 is a diagram illustrating a conventional OFDM receiver;

Fig. 4 is a diagram that is representative of the frequency spectrum of a typical

15   OFDM symbol;

Fig. 5 is a block diagram illustrating an OFDM equalization subsystem in accordance with one embodiment of the present invention;

Fig. 6 is a diagram illustrating the selection of pilot symbols from an OFDM symbol based on a plurality of subcarriers of interest in accordance with one

20   embodiment of the present invention; and

Fig. 7 is a flowchart illustrating a method for performing channel estimation and equalization in an OFDM communication system in accordance with one embodiment of the present invention.

25   DETAILED DESCRIPTION

In the following detailed description, reference is made to the accompanying drawings that show, by way of illustration, specific embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. It is to be understood that the

30   various embodiments of the invention, although different, are not necessarily mutually

exclusive. For example, a particular feature, structure, or characteristic described herein in connection with one embodiment may be implemented within other embodiments without departing from the spirit and scope of the invention. In addition, it is to be understood that the location or arrangement of individual elements within

5   each disclosed embodiment may be modified without departing from the spirit and scope of the invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims, appropriately interpreted, along with the full range of equivalents to which the claims are entitled. In the drawings, like numerals refer to the same or

10   similar functionality throughout the several views.

The present invention relates to computationally efficient techniques and structures for providing channel estimation within a communication system implementing orthogonal frequency division multiplexing (OFDM). The techniques and structures are most useful when only a subset of the subcarriers within each OFDM

15   symbol are of interest. In a system using subcarrier division multiplexing, for example, where subsets of the data subcarriers are assigned to users on a dynamic basis, a communication device associated with a particular user will only be interested in the subcarriers assigned to that user. In one approach, interpolation vectors are first obtained for each of the subcarriers of interest. A dot product is then calculated

20   between each of the interpolation vectors and a pilot vector extracted from a received OFDM symbol. Each dot product results in an equalization coefficient for a corresponding subcarrier of interest. The equalization coefficients are then used to modify the subcarriers of interest within the received OFDM symbol to reduce or remove undesirable channel effects (e.g., frequency selective fading) from the symbol.

25   In one approach, only a subset of the pilot symbols within each OFDM symbol are used to form the pilot vector. The inventive principles are particularly well suited for software implementation (e.g., soft-PHY architectures), although hardware and hybrid software/hardware realizations can also be provided.

Orthogonal frequency division multiplexing (OFDM) is a multi-carrier

30   transmission technique that uses a plurality of orthogonal subcarriers to transmit

information within an available spectrum. Because the subcarriers are orthogonal to one another, they can be spaced much more closely together within the available spectrum than, for example, the individual channels in a conventional frequency division multiplexing (FDM) system. That is, the orthogonality of the subcarriers

5   prevents inter-subcarrier interference within the system. In a typical OFDM system, orthogonality is achieved by using subcarriers that each have a spectrum with a null at the center frequency of each of the other subcarriers. Before transmission, each of the subcarriers is modulated with a low rate data stream. Thus, the transmitted symbol rate of the OFDM system is low and the transmitted OFDM signal is highly tolerant to

10   multipath delay spread within the channel. For this reason, many modern digital communication systems are turning to OFDM as a modulation scheme for signals that need to survive in environments having multipath reflections and/or strong interference. Many wireless communication standards have already adopted OFDM including, for example, IEEE Standard 802.11a, the digital video broadcasting T standard (DVB-T),

15   and the high performance radio local area network standard (HiperLAN). In addition, several industry consortia, including the Broadband Wireless Internet Forum and the OFDM Forum, are proposing OFDM for fixed wireless access systems.

Before a description of the inventive principles is undertaken, a discussion of the basic operating characteristics of a conventional OFDM communication system is

20   presented. It should be appreciated, however, that the inventive principles can be implemented in any communication system utilizing OFDM techniques and are not limited to use within systems or devices having the specific architectures described below.

Fig. 1 is a block diagram illustrating a conventional OFDM transmitter 10. In

25   a typical scenario, the transmitter 10 will be part of a transceiver unit that is capable of supporting duplex communication within a wireless communication system. As illustrated, the transmitter 10 includes: a modulator 12, an inverse fast Fourier transform (IFFT) unit 14, a parallel to serial converter 16, a cyclic extension unit 18, a radio frequency (RF) transmit unit 20, and an antenna 22. The modulator 12 receives

30   a plurality of symbols $(S_0, S_1, S_2, \ldots, S_{N-1})$ that need to be transmitted by the

transmitter 10. The modulator 12 uses each of the input symbols to modulate a corresponding subcarrier of the OFDM system to generate a symbol modulated subcarrier (e.g., S_{0SC}, S_{1SC}, S_{2SC}, . . . , $S_{(N-1)SC}$) at an output thereof. As described above, each of the subcarriers of the OFDM system is orthogonal to each of the other

5   subcarriers to keep inter-subcarrier interference to a minimum. The modulator 12 can use any of a variety of modulation types to modulate the subcarriers (e.g., binary phase shift keying (BPSK), quadrature phase shift keying (QPSK), quadrature amplitude modulation (QAM), differentially coded star QAM (DSQAM), and others). In addition, the modulator 12 can use a different modulation type for each individual

10   symbol or for different groups of symbols if desired.

The input symbols (S_0, S_1, S_2, . . . , S_{N-1}) are used to generate a single OFDM symbol to be transmitted by the transmitter 10. The symbol modulated subcarriers (S_{0SC}, S_{1SC}, S_{2SC}, . . . , $S_{(N-1)SC}$) form a frequency domain representation of the OFDM symbol. The symbol modulated subcarriers are applied to the inputs of the IFFT 14 to

15   generate a time domain representation of the OFDM symbol. As shown, the time domain representation of the OFDM symbol consists of a plurality of time domain samples (s_0, s_1, s_2, . . . , s_{N-1}). Any form of inverse discrete Fourier transform (IDFT) can be used to perform the inverse transform operation. The IFFT is preferred, however, because it is the most computationally efficient method available. As is well

20   known, the number of time domain samples generated by the IFFT 14 is equal to the number of frequency components input thereto (i.e., N).

The samples output by the IFFT 14 are applied to the parallel to serial converter 16 which generates a sample stream representing the OFDM symbol. This serial OFDM symbol is transferred to the cyclic extension unit 18 which adds a cyclic

25   extension (or guard interval) to the OFDM symbol. The cyclic extension is added to the OFDM symbol to prevent the occurrence of inter-symbol interference in the channel that can be caused by the channel's memory (i.e., multipath reflections). The cyclic extension usually consists of a plurality of samples (e.g., N_G samples) that are copied from the end of the serial OFDM symbol and placed at the beginning of the symbol.

30   The number of samples will typically depend upon the memory of the channel. It is

typically desirable to use a cyclic extension having a length that is no more than 10% of the length of the OFDM symbol to maintain efficient (e.g., low overhead) operation.

The cyclic extension unit 18 outputs each OFDM symbol and its corresponding cyclic extension in a continuous stream to the RF transmit unit 20. Fig. 2 is a diagram

5   illustrating the stream output by the cyclic extension unit 18 in a typical application. The RF transmit unit 20 is operative for converting the OFDM symbol stream into a radio frequency signal for transmission into the wireless channel. To perform this function, the RF transmit unit 20 may include, for example, a digital to analog converter, a frequency conversion unit (e.g., an up converter), a power amplifier, and/or

10   any other equipment required to generate an RF transmit signal. The output of the RF transmit unit 20 is delivered to the antenna 22 which transmits a radio frequency communication signal 24 into the channel. It should be appreciated that other processing functionality, such as error coding circuitry, may also be included within the OFDM transmitter 10.

15   Fig. 3 is a block diagram illustrating a conventional OFDM receiver 28. Like the transmitter 10 of Fig. 1, the receiver 28 will typically be part of a transceiver unit that is capable of supporting duplex communications within a wireless communication system. As illustrated, the receiver 28 includes: an antenna 30, an RF receive unit 32, a synchronization unit 34, a serial to parallel converter 36, an FFT unit 38, and a

20   demodulation unit 40. The antenna 30 receives an RF communication signal 24 from the channel. The RF receive unit 32 converts the received RF signal to a format required for subsequent processing. The RF receive unit 32 may include, for example, a low noise amplifier, one or more frequency conversion units (e.g., a down converter), an analog to digital converter, and/or any other functionality required to achieve the

25   desired signal format. The RF receive unit 32 transfers the received signal to the synchronization unit 34 which synchronizes the signal in a manner that allows the individual OFDM symbols within the signal to be recognized and the cyclic extensions to be discarded. The OFDM symbols are delivered one after the other to the serial to parallel converter 36 which converts each symbol into a parallel group of time domain

30   samples $(r_0, r_1, r_2, \ldots, r_{N-1})$. The samples are input into the FFT unit 38 which

generates a plurality of frequency domain symbol modulated subcarriers (R_{0SC}, R_{1SC}, R_{2SC}, ..., $R_{(N-1)SC}$). The symbol modulated subcarriers are then demodulated by the demodulator 40 to produce a plurality of symbols (R_0, R_1, R_2, ..., R_{N-1}).

5   The impulse response of the wireless channel (i.e., the channel impulse response or CIR) is typically assumed to be time-invariant for the duration of one OFDM symbol. Thus, the time domain convolution of the transmitted time domain signal with the CIR is equivalent to the multiplication of the spectrum of the transmitted signal with the frequency domain transfer function H(f) of the channel (which is simply the Fourier transform of the CIR). Each of the frequency domain symbol modulated

10   subcarriers (R_{0SC}, R_{1SC}, R_{2SC}, ..., $R_{(N-1)SC}$) that are received by the receiver 28, therefore, is the product of a corresponding symbol modulated subcarrier (S_{0SC}, S_{1SC}, S_{2SC}, ..., $S_{(N-1)SC}$) of the transmitter 10 and an associated coefficient of the frequency domain transfer function H(f) of the channel, plus some additive channel noise (e.g., additive white Gaussian noise). This can be expressed in equation form as follows:

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$$R_{nSC} = S_{nSC} \times H_n + n_n$$

where R_{nSC} is the nth symbol-modulated subcarrier received in the receiver, S_{nSC} is the nth symbol-modulated subcarrier transmitted by the transmitter, H_n is the frequency

20   domain channel transfer function coefficient corresponding to the nth subcarrier, and n_n is a white Gaussian noise sample corresponding to the nth subcarrier. As coherent detection is assumed for the system, the received data symbols R_{nSC} need to be de-faded in the frequency domain. Thus, an estimate of the frequency domain transfer function H(f) of the channel needs to be made.

25   In a typical approach, the channel transfer function is estimated using pilot symbols that are included within the OFDM symbols transmitted by the transmitter 10. The pilot symbols are usually located at fixed frequency intervals within the OFDM symbols. Fig. 4 is a diagram illustrating the frequency spectrum of an OFDM symbol 42 having a plurality of subcarriers. As shown, every fourth subcarrier within the

30   OFDM symbol 42 includes a pilot symbol 44 that can be used for channel estimation.

The other subcarriers within the OFDM symbol 42 are used to carry user data symbols through the channel. The spacing of the pilot symbols 44 within a particular OFDM symbol will typically depend upon the specific system being implemented. Similarly, the overall number of subcarriers within each OFDM symbol will also be system specific. The location and content of the pilot symbols within the transmitted OFDM symbol will typically be known within the receiver.

When an OFDM symbol is received by the receiver 28, the pilot symbols are extracted from the received signal. The extracted pilot symbols include information about the frequency domain transfer function of the channel (e.g., coefficients) at the frequencies of the pilot carrying subcarriers. To obtain information about the frequency domain transfer function of the channel at the frequencies of the data carrying subcarriers, interpolation techniques are often used. In the simplest approach, linear interpolation is performed from pilot to pilot. This method provides reasonable performance as long as the inverse of the realized delay spread does not approach the pilot spacing. Often, however, the linear approach falls short of the performance levels required in modern communication systems.

In an "optimal" interpolation method, zero-padded FFTs (or DFTs) are used to fill in the missing transfer function coefficients. This method will typically result in the most accurate channel estimate available, but it is very computationally complex. For example, in a typical procedure, the pilots from a received OFDM symbol are input to an FFT to generate an array of values at an output of the FFT. The number of values within the array output by the FFT is equal to the number of pilots input to the FFT (i.e., M). A plurality of zeros is then added to the array of values to increase the total number of values to the number of subcarriers within the OFDM symbol (i.e., from M to N). This process is known as zero-padding. An inverse N-point FFT is then performed on the zero-padded array to achieve interpolated channel transfer function coefficients for all of the subcarriers. These coefficients can then be used to perform channel equalization for the data carrying subcarriers within the received OFDM symbol on a subcarrier by subcarrier basis (e.g., by simple division).

In conceiving the present invention, it was appreciated that many situations exist where only a subset of the subcarriers within a particular OFDM symbol are of interest. For example, in an OFDM system where orthogonal frequency division multiple access (OFDMA) is being utilized, individual users are each assigned subsets

5 of the subcarriers on a dynamic basis. Thus, the communication equipment associated with a particular user (e.g., a handheld communicator) will only be concerned with the corresponding subcarriers assigned to that user and not the entire subcarrier array. In a similar example, a basestation in an OFDM system implementing OFDMA will typically receive OFDM signals from multiple user terminals concurrently. The base

10 station must then estimate the channel associated with each user terminal separately. Each channel estimation, therefore, is only concerned with the subcarriers of interest for the corresponding user terminal. Other situations also exist where only a subset of the subcarrier array is of interest. In these situations, it will often be inefficient to perform the computationally complex optimal interpolation technique described above

15 to determine equalization coefficients for the subcarriers of interest. Therefore, in accordance with the present invention, techniques are presented that are capable of providing a significant reduction in the computational complexity associated with channel estimation (i.e., with respect to the optimal interpolation approach) when only a subset of subcarriers within an OFDM symbol are of interest. The techniques of the

20 present invention will typically provide a performance level between that of the linear interpolation method and the optimal interpolation method (often closer to the optimal method).

The reduced complexity channel estimation techniques of the present invention are derived from the optimal interpolation approach described above. In the optimal

25 approach, a pilot vector having a length M (extracted from a received OFDM symbol) is transformed into a vector of length N using zero padded FFTs (or DFTs). An M-point FFT is first performed on the pilot vector x_n as follows:

$$X_f = \sum_{n=0}^{M1} x_n \cdot e^{-j2\pi fn/M}$$

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where X_f are the frequency domain coefficients output by the FFT, M is the number of pilots in the pilot vector, n is the time index, and f is the frequency index. The resulting group of coefficients X_f is then zero-padded to length N (i.e., total number of subcarriers within the OFDM symbol) with the zeros inserted in the high frequency (center) terms. An N-point inverse FFT (or DFT) is then performed on the zero-padded array to generate a plurality of interpolated equalization coefficients x_n' that can be described as follows:

$$\hat{x}_n = \sum_{f=0}^{(M/2)-1} X_f \cdot e^{j2\pi fn/N} + \sum_{f=N-(M/2)}^{N-1} X_{f-N+M} \cdot e^{j2\pi fn/N}$$

The subscript of X has been modified in the second summation of this equation to conform to the original, non-zero padded indicies described above. Substituting the second equation into the first and expanding the result yields:

$$\hat{x}_k = e^{j\cdot 0} \cdot \sum_{n} x_n \cdot e^{-j\cdot 0} + e^{j2\pi k/N} \cdot \sum_{n} x_n \cdot e^{-j2\pi n/M}$$

$$+ e^{j2\pi k2/N} \cdot \sum_{n} x_n \cdot e^{-j2\pi n2/M} + \cdots$$

$$+ e^{j2\pi((M/2)-1)k/N} \cdot \sum_{n} x_n \cdot e^{-j2\pi n((M/2)-1)/M}$$

$$+ e^{j2\pi(N-(M/2))} \cdot \sum_{n} x_n \cdot e^{-j2\pi n(N-(M/2)-N+M)/M} + \cdots$$

$$+ e^{j2\pi(N-1)k/N} \cdot \sum_{n} x_n \cdot e^{-j2\pi n(M-1)/M}$$

where the index k has been introduced to distinguish the indicies of x' from the indicies of x. It was determined by rearranging the terms of this equation (to combine x_n) that each element of x' is simply the dot product of x (the pilot vector) with an interpolation vector I having length M. For arbitrary k and N, the interpolation vector I can be calculated as follows:

$$I_n = \sum_{i=0}^{M-1} e^{j2\pi((k/N)-n/M))} + \sum_{i=N-(M/2)}^{N-1} e^{j2\pi((i \cdot k/N)-((i-N-M) \cdot n/M))}$$

In accordance with one aspect of the present invention, a plurality of interpolation vectors are predetermined (using the above equation or some variant thereof) and stored within a communication device. When an OFDM symbol is received by the communication device, a pilot vector is extracted from the OFDM symbol. Interpolation vectors are then retrieved for each subcarrier of interest within the communication device and a dot product is calculated between the pilot vector and each of the retrieved interpolation vectors. Each dot product results in an equalization coefficient for a corresponding subcarrier of interest. This basic approach will be referred to herein as the vector interpolation method (VIM). The equalization coefficients resulting from the dot products are then used to equalize the associated subcarrier signals within the OFDM symbol (e.g., by division). As long as the subcarriers of interest remain unchanged, the same interpolation vectors can be used to process each OFDM symbol received from the channel.

The VIM offers a computational flexibility that was not previously available using the optimal interpolation approach. For example, the VIM allows flexibility in block size (i.e., the number of subcarriers computed) and pilot vector size that was not previously available. Using the VIM, an OFDM communication system can be implemented that allows the number of subcarriers assigned to each user to be dynamically varied during system operation. Similarly, an OFDM system can be provided that allows the total number of subcarriers and/or pilot symbols within each OFDM symbol to be dynamically varied. Theoretically, the optimal interpolation

method can be performed with only a subset of the pilot symbols within an OFDM symbol to reduce computational complexity. However, to dynamically vary the size of the pilot vector used to perform optimal interpolation during system operation, block processing elements (e.g., FFTs) would have to be available for each expected vector

5   size. As dedicated hardware is typically used to perform the FFTs using the optimal approach, this could easily become cost prohibitive. For this reason, systems implementing the optimal approach typically employ the entire array of pilots to perform the interpolation. For a given number of pilots used, the optimal method and the VIM will provide identical performance. However, when the number of subcarriers

10   to be interpolated is a subset of those traversed by the pilot tones used in the channel estimation, a significant computation benefit is achieved by using the VIM. Thus, the VIM allows channel estimation to be performed only in the region of the subcarriers of interest in a relatively simple and dynamic fashion, usually with a reduced computational requirement. In addition, the VIM is particularly well suited for

15   implementation within a soft-PHY architecture.

Fig. 5 is a block diagram illustrating an OFDM equalization subsystem 50 in accordance with one embodiment of the present invention. The subsystem 50 will typically be implemented as part of a wireless receiver (e.g., receiver 28 of Fig. 3) in an OFDM communication system. In a multi-user basestation scenario, a separate

20   equalization subsystem 50 can be provided for each user currently communicating with the basestation. It should be appreciated that the individual blocks within the block diagram do not necessarily correspond to discrete hardware structures. For example, one or more of the blocks (or all of the blocks) may be implemented in software within a digital processing device.

25   As illustrated, the equalization subsystem 50 includes: a subcarrier tracking unit 52, a pilot vector unit 54, an interpolation vector retrieval unit 56, a computation unit 58, an equalizer 60, and a memory 62. The subcarrier tracking unit 52 tracks the current subcarriers of interest for the subsystem 50. The pilot vector unit 54 extracts a number of pilot symbols from a recently received OFDM symbol 64 to form a pilot

30   vector. The interpolation vector retrieval unit 56 retrieves a plurality of interpolation

vectors corresponding to the subcarriers of interest identified by the subcarrier tracking unit 52 from the memory 62. As will be described in greater detail, the interpolation vector retrieval unit 56 may use information about the pilot symbols within the pilot vector to determine which interpolation vectors to retrieve. The computation unit 58

5   uses the pilot vector from the pilot vector unit 54 and the interpolation vectors from the interpolation vector retrieval unit 56 to generate a plurality of equalization coefficients for delivery to the equalizer 60. The equalizer 60 then uses the equalization coefficients generated by the computation unit 58 to equalize each of the subcarriers of interest within the corresponding OFDM symbol 64. This procedure is repeated for each

10   OFDM symbol received.

As described above, the subcarrier tracking unit 52 is operative for tracking the subcarriers of interest within the equalization subsystem 50. To do this, the subcarrier tracking unit 52 will typically need to determine which subcarriers are presently assigned to a user associated with the subsystem 50. In a basestation that is servicing

15   multiple users within the OFDM system, a separate equalization subsystem 50 may be provided for each currently connected user. The subcarrier tracking unit 52 within each subsystem 50 would thus track the subcarriers assigned to the corresponding user. The subcarrier tracking unit 52 will output an indication of the present subcarriers of interest to the interpolation vector retrieval unit 56 and possibly the pilot vector unit 54. In at

20   least one approach, the number and location of the subcarriers of interest associated with a particular user can change with time. The subcarriers of interest associated with a particular user are not necessarily adjacent to one another within the OFDM symbol.

In one embodiment of the present invention, the pilot vector generated by the pilot vector unit 54 includes all of the pilot symbols from the present OFDM symbol

25   64. In a preferred approach, however, the pilot vector unit 54 includes selection functionality for dynamically selecting a subset of pilot symbols within the OFDM symbol 64 to be used to form the pilot vector (i.e., to perform the interpolation). By using a subset of pilot symbols, computational complexity can be reduced considerably. However, as discussed previously, a reduction in equalization performance will usually

30   be experienced. In this regard, a tradeoff can be made between performance and

computational efficiency. The subset of pilot symbols that is used within the vector interpolation calculations should envelope all of the subcarriers of interest being processed. For example, with reference to Fig. 6, if subcarriers 66, 68, 70, 72, and 74 are presently of interest, then at least pilot symbols A, B, C, and D should be used in

5   the interpolation. The pilot vector unit 54 can determine which of the pilot symbols to use for a particular set of subcarriers of interest based on the interpolation vectors that are known to be available within the memory 62.

The memory 62 will include a plurality of interpolation vectors for use during the channel estimation process. The interpolation vectors can all have the same length

10   or a plurality of different length interpolation vectors can be provided. The interpolation vectors will typically be calculated a priori using the interpolation vector equation described above or a similar equation. In a system where the number and arrangement of the subcarriers of interest can vary, the length of the corresponding pilot vectors may also vary. In this scenario, interpolation vectors can be stored in the

15   memory 62 for each subcarrier within each possible pilot vector arrangement. The interpolation vector retrieval unit 56 retrieves the appropriate interpolation vectors from the memory 62 based on the subcarriers identified by the subcarrier tracking unit 52. If the pilot vector unit 54 dynamically selects pilot symbols for the pilot vector, the interpolation vector retrieval unit 56 will also use information about the present pilot

20   vector to retrieve the appropriate interpolation vectors. As described previously, the retrieved interpolation vectors will each have the same length as the pilot vector assembled by the pilot vector unit 54. In a preferred approach, the computation unit 58 calculates a separate dot product between the pilot vector and each of the retrieved interpolation vectors. The result of each dot product is the equalization coefficient for

25   the corresponding subcarrier of interest. The equalizer 60 equalizes the subcarriers of interest within the present OFDM symbol 64 by dividing each subcarrier by the corresponding equalization coefficient. The equalized data symbols are then output for further processing.

Fig. 7 is a flowchart illustrating a method for performing channel estimation and

30   equalization in an OFDM communication system in accordance with one embodiment

of the present invention. A plurality of subcarriers of interest are first identified (block 70). A pilot vector is then extracted from a received OFDM symbol (block 72). The pilot vector can include all of the pilot symbols from the OFDM symbol or a subset thereof. In at least one embodiment, pilot symbols are chosen for the pilot vector based

5 on the quantity and location of the subcarriers of interest. An interpolation vector is obtained for each of the identified subcarriers of interest (block 74). In a preferred approach, the interpolation vectors are retrieved from a memory within the corresponding communication unit. However, other methods for obtaining the interpolation vectors can also be used. A dot product is next calculated between the

10 pilot vector and each of the interpolation vectors (block 76). Each dot product results in an equalization coefficient for a corresponding subcarrier of interest. Each equalization coefficient is then applied to a corresponding subcarrier within the received OFDM symbol (block 78). This process is repeated for each OFDM symbol received.

15 It should be appreciated that the principles of the present invention can be beneficially implemented in any receiver unit used within an OFDM-based communication system. The receiver unit can be located, for example, within a multi-user basestation, a single user handheld communicator, a satellite uplink, downlink, or crosslink transceiver, a transceiver supporting a terrestrial wireless link, mobile

20 transceivers within ad hoc networks, and in a wide variety of other communication device types. The inventive principles have application in both wireless and wired systems, although wireless systems will typically derive the greatest benefit.

Although the present invention has been described in conjunction with certain embodiments, it is to be understood that modifications and variations may be resorted

25 to without departing from the spirit and scope of the invention as those skilled in the art readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and the appended claims.